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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/911,155	07/23/2001	Primit Parikh	P0164US7	4496

7590 12/24/2002  
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EXAMINER

HU, SHOUXIANG

ART UNIT	PAPER NUMBER
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2811

DATE MAILED: 12/24/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

**Office Action Summary**

Application No.

09/911,155

Applicant(s)

PARIKH ET AL.

Examiner

Shouxiang Hu

Art Unit

2811

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☐ Responsive to communication(s) filed on 15 October 2002.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-57 is/are pending in the application.
- 4a) Of the above claim(s) 9-13, 25-27, 29-42, 50, 51, 54, 55 and 57 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-8, 14-24, 28, 43-49, 52, 53 and 56 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

**Priority under 35 U.S.C. §§ 119 and 120**

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

**Attachment(s)**

- 1) ☒ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). \_\_\_\_\_
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) \_\_\_\_\_ 6) ☐ Other: \_\_\_\_\_

## **DETAILED ACTION**

### ***Election/Restriction***

1. Claims 9-13, 25-27, 29-42 and 50-51 are withdrawn from further consideration pursuant to 37 CFR 1.142(b), there being no allowable generic or linking claim. The election was made in Paper No. 5.
2. In addition, it is noted that the newly added claims 52 and 53 are treated by the Office as a replacement for the claims 52 and 53 added in the previous amendment (paper No. 7) filed by applicant on 6/27/02. And, claims 54, 55 and 57 added in the previous amendment are also withdrawn from further consideration pursuant to 37 CFR 1.142(b), for being unreadable on the elected species, as explained in the previous Office action.
3. Accordingly, claims 1-57 are pending in this application, and claims 1-8, 14-24, 28, 43-49, 52, 53 and 56 remain active in this office action.

### ***Claim Objections***

4. Claims 1-8, 14-24, 28, 52, 53, and 56 are objected to because of the following informalities and/or defects:

In claims 1-8, 14-24, 28, 52, 53, and 56, the relationships among the terms of "barrier potential energy level", "barrier height" and "barrier potential" are not clearly defined.

In claims 6, 22 and 49, the term of "the group comprising" should read as --the group consisting of--; otherwise it would be indefinite as to what else is/are included in the group.

In claim 15 and its relevant dependent claims, the term of "lower doped" should read as --lightly doped--.

In claim 28, the term of "higher" should read as --highly--

In addition, in claim 49, the term of "with similar work functions" should read as --with work functions similar to that of Cr, Nb, Sn, W and Ta--.

In claim 56, the term of "is such that", should read as --is sufficiently low so that--. And, claim 56 also fails to sufficiently further limit the subject matter of claim 1. Applicant is recommended to cancel the claim, or amend the claim to place it in proper dependent form.

Appropriate correction is required.

### ***Claim Rejections - 35 USC § 112***

5. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 1-8, 14-24, 28, 43-49 and 56 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 1, 15, 29 and 42 recite the subject matter that the Schottky barrier height is lower enough to allow low forward voltage operation of the diode, but fails to define how low the low forward voltage should

be in order to be regarded as a low forward voltage, since a Schottky barrier can have a barrier height as high as 3 eV, and numerous other diodes having a Schottky barriers lower than that would then have a low forward voltage, but many of them may not be readable on the instant invention.

7. Claims 52 and 53 are rejected under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential elements, such omission amounting to a gap between the elements. See MPEP § 2172.01. The omitted elements are: the material for the Schottky metal layer that is essential to the realization of the claimed low forward voltage of 0.1 to 0.3 volts.

### ***Claim Rejections - 35 USC § 103***

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. Claims 1-5, 7-8, 14-21, 23-24, 28, 43-49, 52, 53 and 56, insofar as being in compliance with 35 U.S.C. 112, are rejected under 35 U.S.C. 103(a) as being unpatentable over Binari et al. ("Binari"; Electronics Letters, May 26, 1994, V30, N11, pages 909-911) in view of Mohammad et al. ("Mohammad"; Electronics Letters, March 14, 1996, V32, N6, pages 598-599).

Binari discloses a gallium nitride based diode (see the right column on page 909), comprising: an n- GaN layer ( $4 \times 10^{17} \text{ cm}^{-3}$ ) over a sapphire substrate; a Schottky

metal (Ti) forming a junction with the n- GaN layer with an unpinned Fermi level (see the abstract), And, it is noted that, in such a junction, the junction barrier potential is inherently unpinned and is inherently approximately equal to the work function of the Schottky metal minus the electron affinity of the n- GaN layer, according to the well recognized basic characteristics of a Schottky diode (e.g., see Ng, Complete Guide to Semiconductor Devices, McGraw-Hill, Inc., 1995, pages 30-39).

Although Binari does not expressly disclose that the diode can further comprise an n+ GaN layer between the n- GaN layer and the substrate with an ohmic contact formed on the n+ GaN layer, one of ordinary skill in the art would readily recognize that such an n+ GaN layer and ohmic contact layer can be desirably included in a Schottky diode for reducing its on-resistance, as evidenced in Mohammad (see the ohmic contact to the n+ GaN layer ( $5 \times 10^{18} \text{cm}^{-3}$ )).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the n+ GaN layer and the ohmic contact of Mohammad into the gallium nitride-based diode of Binari, so that a diode with a reduced on-resistance would be obtained. And, the barrier height in such a diode would be inherently low enough to allow the operation of the diode with a forward voltage as low as the one in the claimed invention, as such a diode would be formed of a material set same as that of a preferred one in the instant invention (see page 10, lines 12-17, in the specification of the instant invention).

Regarding claim 49, it is noted that Ti inherently has a work function similar to that of Cr Nb, Sn, W or Ta (see American Institute of Physics Handbook; pages 9-172–9-177, 1982).

10. Claims 6 and 22, insofar as being in compliance with 35 U.S.C. 112, are rejected under 35 U.S.C. 103(a) as being unpatentable over Binari in view of Mohammad, as applied to claims 1-5, 7-8, 14-21, 23-24, 28, 43-49, 52, 53 and 56 above, and further in view of American Institute of Physics Handbook ("AIPH"; pages 9-172–9-177, 1982) and/or Denisenko et al. ("Denisenko"; Device Research Conference, Denver, CO, USA, pages 75-76, June 2000).

The disclosures of Binari and Mohammad are discussed as applied to claims 1-5, 7-8, 14-21, 23-24, 28, 43-49, 52, 53 and 56 above.

Although Binari and Mohammad do not expressly disclose that the Schottky metal can also be Cr, one of ordinary of ordinary skill in the art would readily recognize that Cr can also be used as the Schottky metal for better material choices, since the its work function is similar to that of Ti, as evidenced in AIPH, and it is also an art-known Schottky metal for GaN diodes, as evidenced in Denisenko (see Fig. 1 at page 76).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to make the above gallium nitride-based diode collectively taught by Binari and Mohammad with the Schottky metal being made of Cr, per the teachings of AIPH and/or Denisenko, so that a diode with similar performance would be obtained with better material choices.

***Response to Arguments***

11. Applicant's arguments with respect to claims 1-8, 14-24, 28, 43-49, 52, 53 and 56 have been considered but are moot in view of the new ground(s) of rejection.

***Conclusion***

12. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Shouxiang Hu whose telephone number is (703) 306-5729. The examiner can normally be reached on Monday through Thursday, 7:30 AM to 6:00 PM.




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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tom Thomas can be reached on (703) 308-2772. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9318 for regular communications and (703) 872-9319 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

SH  
December 19, 2002

  
Shouxiang Hu  
Patent Examiner  
TC2800